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H4D
H4F

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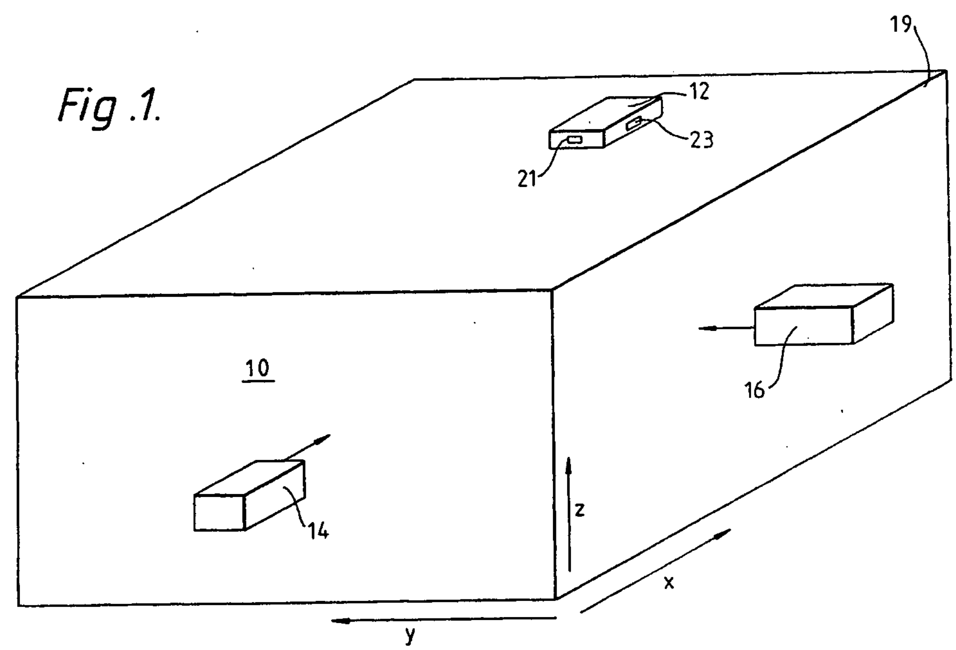
(54) A system and a method f r detecting the position of an object

(57) The position of an object 12 e.g. a manipulator, in an enclosure 10 is detected by two video cameras 14, 16 from which signals representative of images in the cameras 14, 16 are supplied to a mini-comuter (30). The mini-computer (30) scans the signals to detect the position of the object 12 in the signals, and relates this position to the spatial coordinates of the object 12 in the enclosure 10. Means are provided for controlling the movement of the object 12 within the enclosure, which may be a hostile environment e.g. radio-active.

Fig .1.



The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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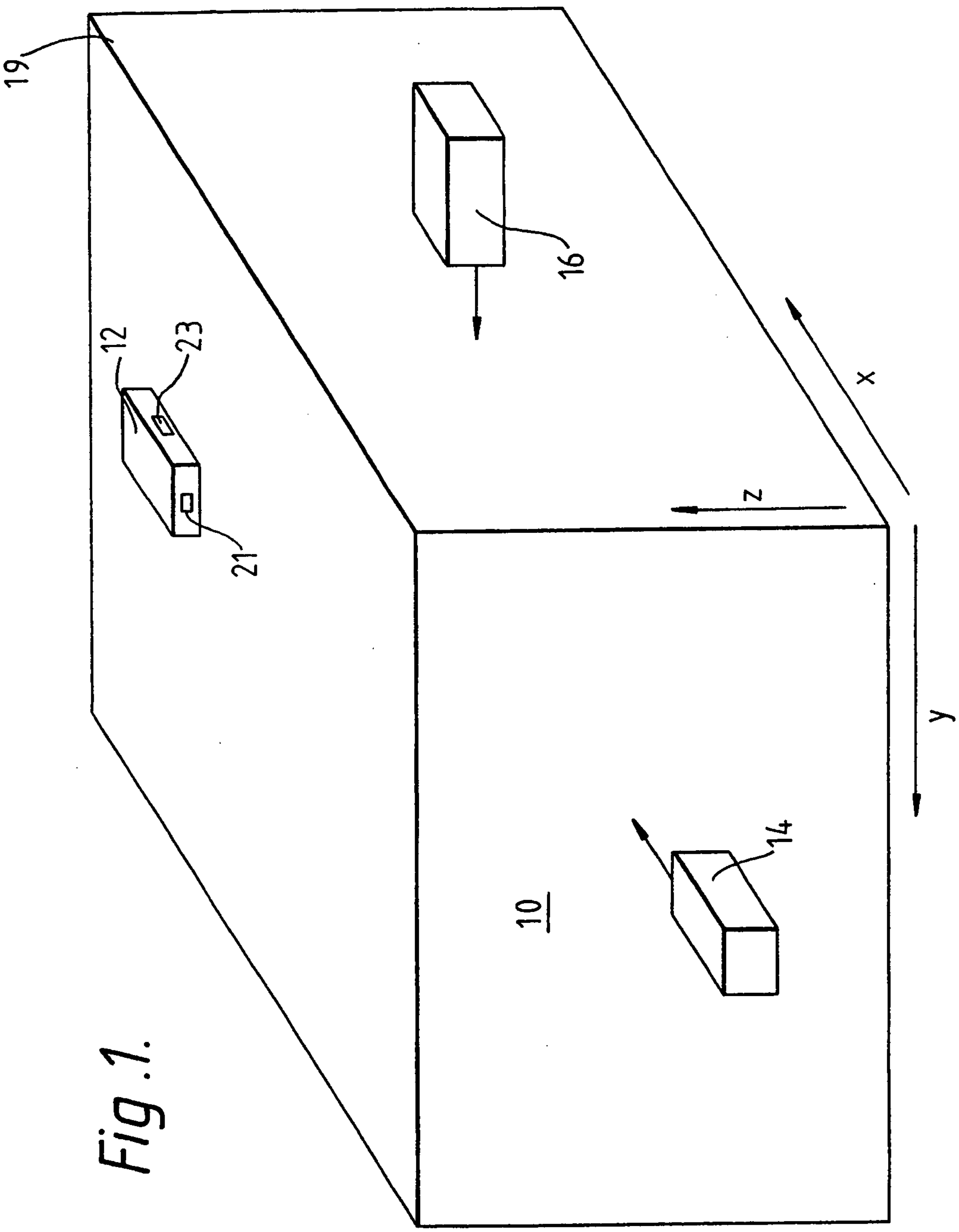


Fig.1.

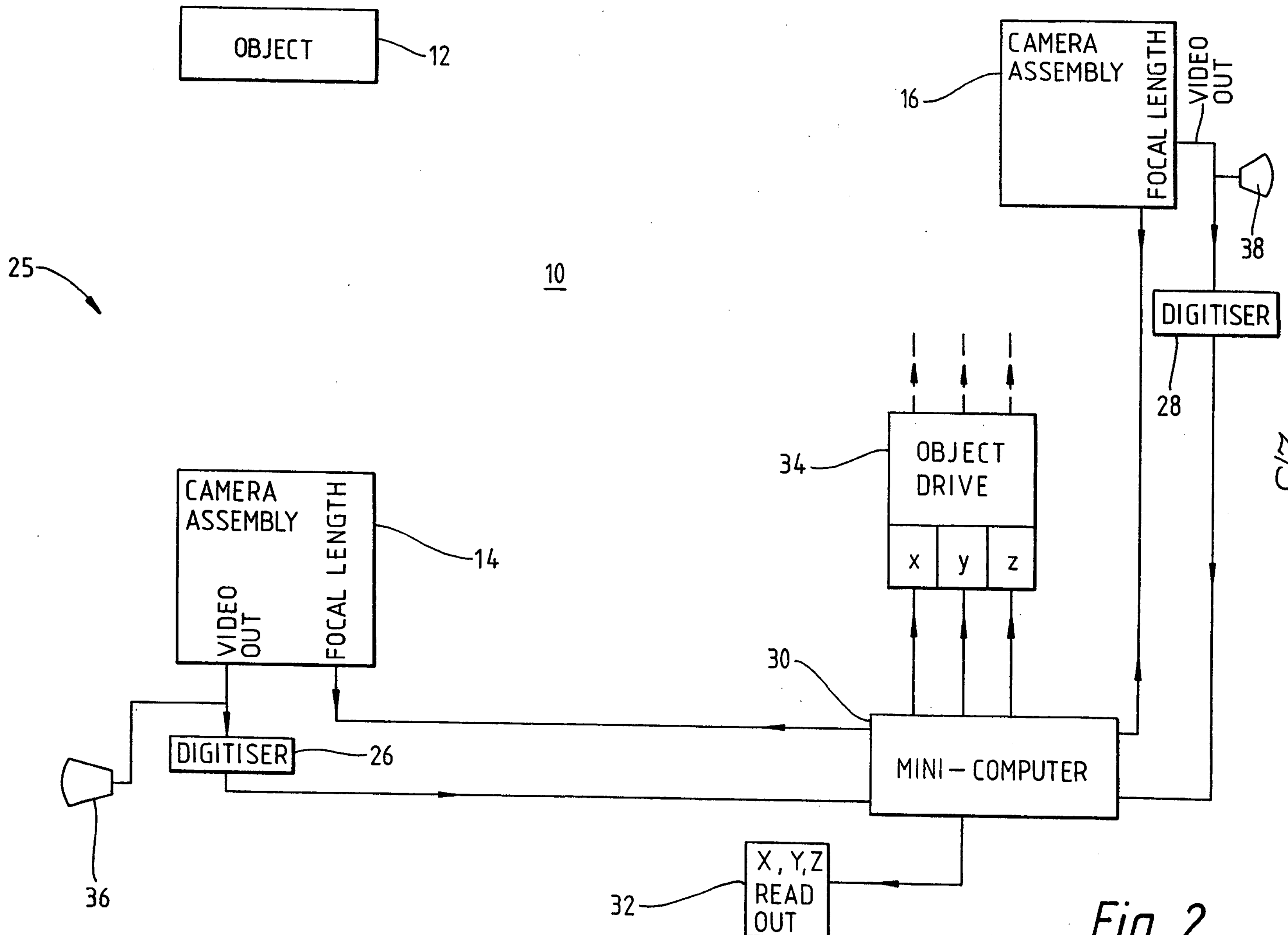

OBJECT
12
25
10
CAMERA ASSEMBLY
FOCAL LENGTH
VIDEO OUT
16
38
DIGITISER
28
OBJECT DRIVE
x
y
z
34
CAMERA ASSEMBLY
VIDEO OUT
FOCAL LENGTH
14
30
DIGITISER
26
MINI – COMPUTER
36
X, Y, Z READ OUT
32

Fig. 2.

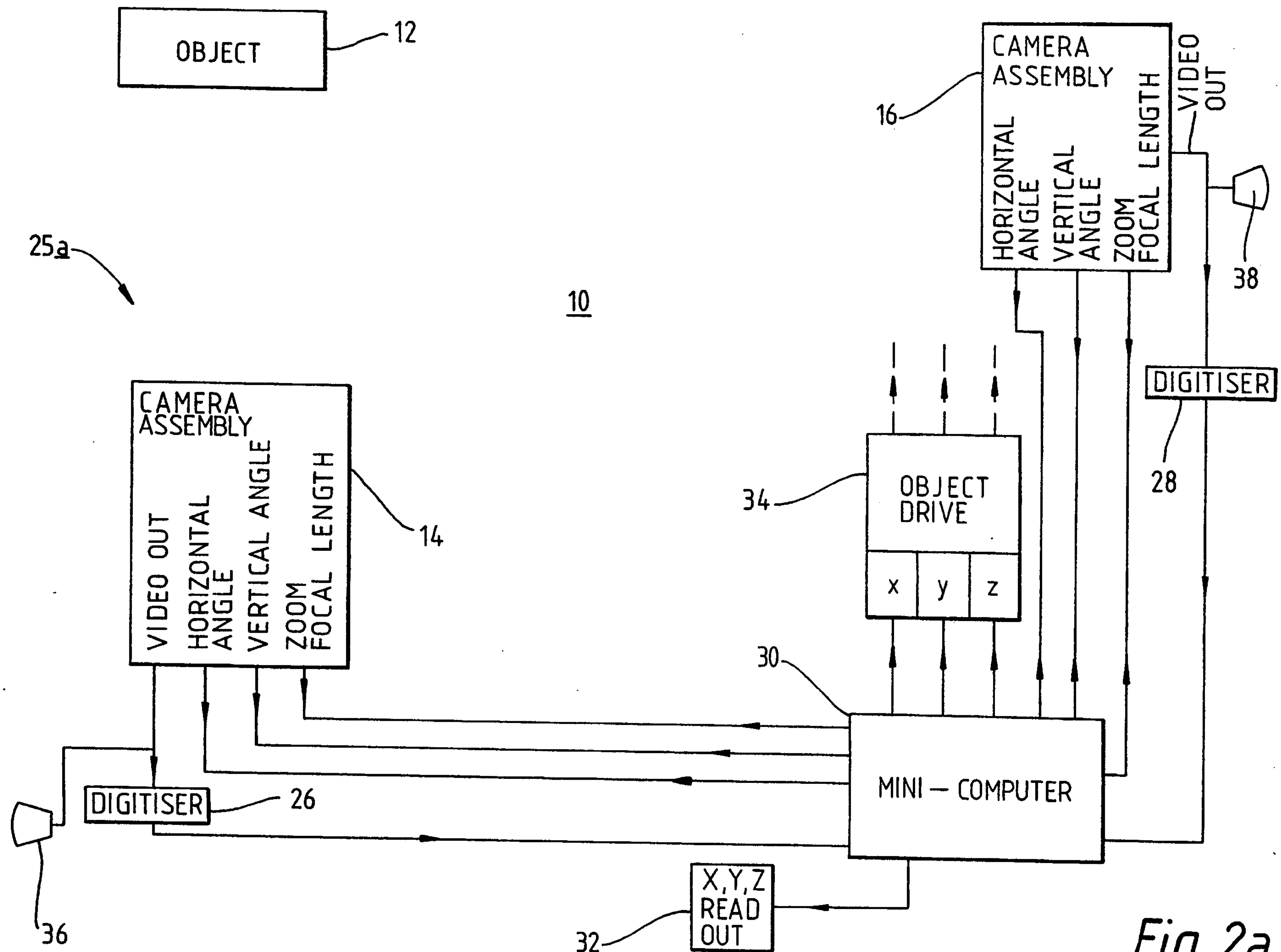

OBJECT
12
25a
10
CAMERA ASSEMBLY
VIDEO OUT
HORIZONTAL ANGLE
VERTICAL ANGLE
ZOOM
FOCAL LENGTH
14
CAMERA ASSEMBLY
HORIZONTAL ANGLE
VERTICAL ANGLE
ZOOM
FOCAL LENGTH
VIDEO OUT
16
38
DIGITISER
28
OBJECT DRIVE
x
y
z
34
30
MINI — COMPUTER
DIGITISER
26
36
X,Y,Z READ OUT
32

Fig.2a.

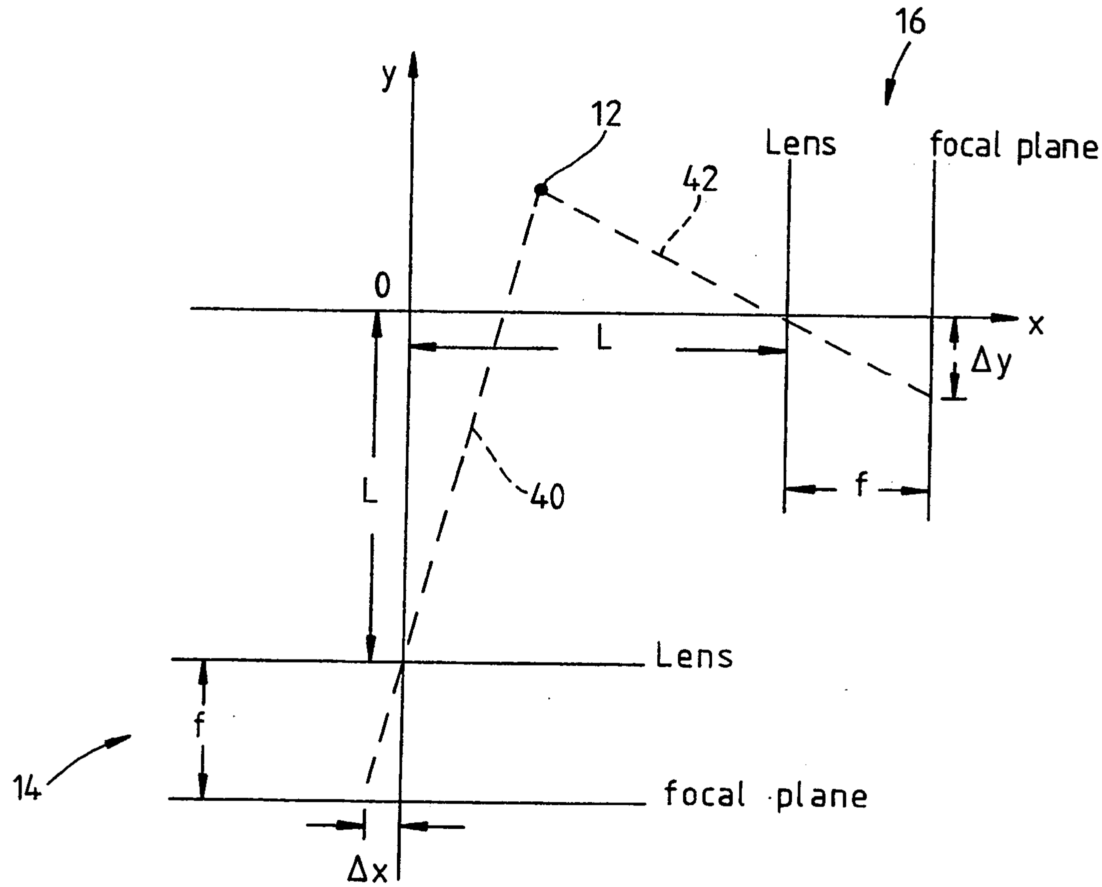
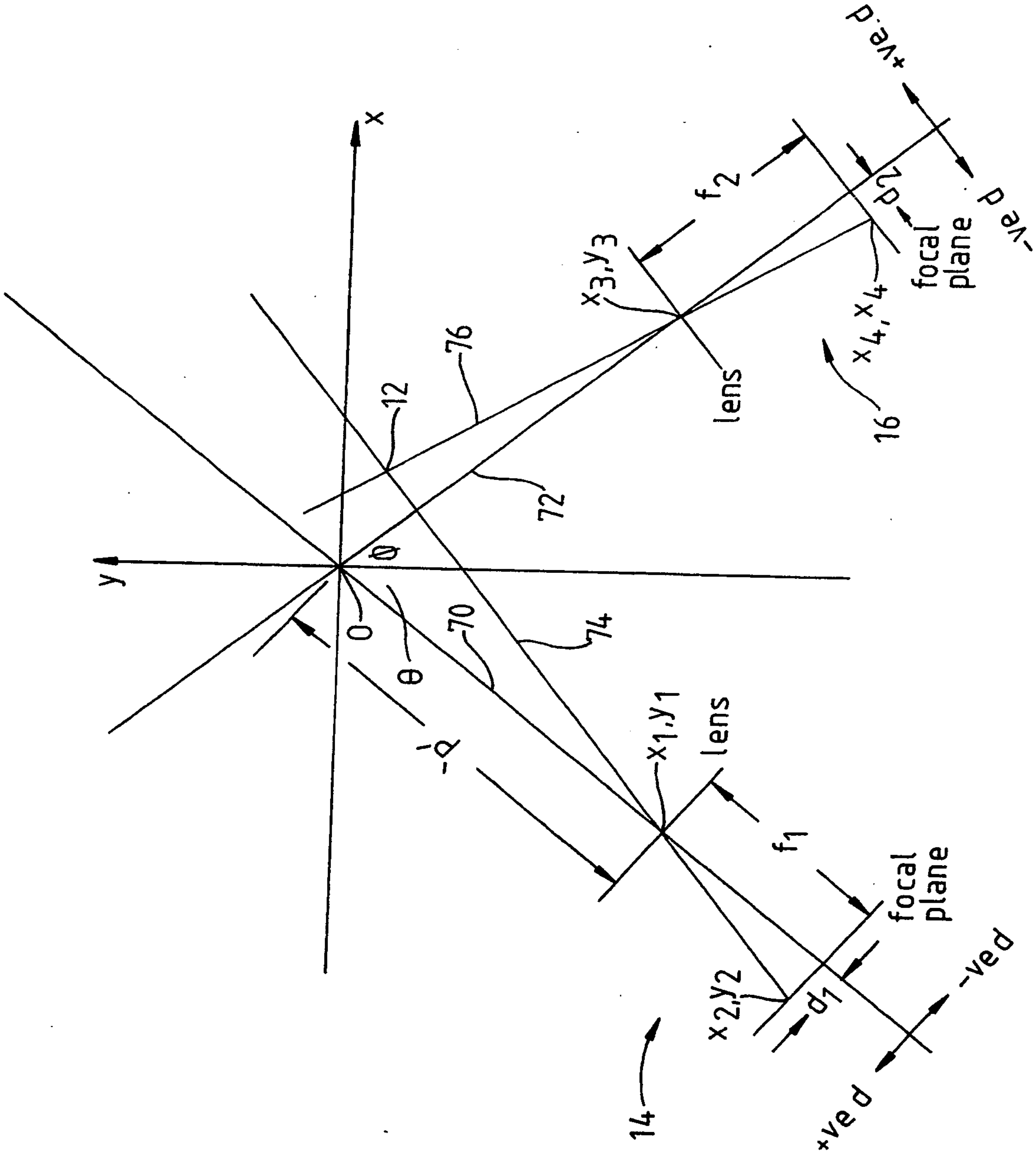


Fig.3.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74
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lens
focal plane
focal plane
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f_2
d_1
d_2
x_1,y_1
x_2,y_2
x_3,y_3
x_4,x_4
+ve d
-ve d
+ve d
-ve d
14
16

Fig.4.

SPECIFICATION

A system and a method for detecting the position of an object

This invention relates to a system and to a method for detecting the position of an object, and in particular to detection by non-contact means of a movable object.

When an object such as a crane or a manipulator is sited in a hostile environment, an operator is usually separated from the object by a physical barrier, for example, a biological shield of a radioactive enclosure. Direct viewing of the object by the operator in such circumstances is necessarily restricted, and in some instances reliance has to be placed on a closed circuit television viewing system. However, with such a system which provides a two-dimensional image of the scene being screened, the lack of stereoscopic vision hinders accurate positioning of the object.

The invention therefore in a first aspect provides a system for detecting the position of a movable object in an environment, the system comprising at least two camera means for viewing the environment, means for transmitting from each said camera means signals representative of an image in each said camera means, and control means, said control means including means for receiving said signals and for scanning the signals to identify the position of the object in said signals and means for deducing the spatial coordinates of said position with respect to said environment.

The control means may include means for controlling the movement of the object in the environment, and each said camera means may be angularly displaceable, preferably under the control of the control means, about mutually perpendicular axes.

Advantageously, indicium means in the form of targets or patterns uniquely coded are attachable to said object, and each said camera means may include zoom lens means controllable from the control means for improving the resolution of the indicium means.

Advantageously, the movements of the object may be controlled by the control means, for example to move the object to a selected position or to avoid intrusion of the object into prohibited portions of the environment.

The coordinates may be in a horizontal plane and/or in a vertical plane, and conveniently the coordinates may be displayed on read-out means connectable to the control means.

The camera means may be disposed at the same side of the environment or at adjacent sides thereof, for example to provide orthogonal viewing of the environment, and the transmitting means may include digitiser means for digitising the representative signals from the camera means.

The invention also includes a method of detecting the position of a movable object in an environment, the method comprising, viewing the environment with two spaced apart camera means, transmitting from the camera means signals representative of images in each said camera means, scanning said signals to identify the position of the object in said signals, and deducing the spatial coordinates of the object from said location.

The method desirably includes panning and tilting the camera means, and preferably includes, controlling the movement of the object so as to move the object to a selected position in the environment, said movement being controlled in a manner to avoid the object moving through prohibited portions in the environment.

The invention will now be further described by way of example only with reference to the accompanying drawings, in which:-

Figure 1 shows a perspective diagrammatic representation of an enclosure;
Figure 2 shows schematically a system for detecting the position of an object in the enclosure of Figure 1;
Figure 2a shows a modification of the system of Figure 2;
Figure 3 shows diagrammatically part of the system of Figure 2; and
Figure 4 shows diagrammatically a modification of part of the system of Figure 2*a*.

In the above Figures, like parts have like numerals.

Referring now to Figure 1, an enclosure 10 is shown in which an object 12 is disposed. Two video camera assemblies 14, 16 respectively are located at mutually perpendicular vertical sides 18, 19 of the enclosure 10, and two indicia 21, 23 are attached to the object 12 such that the indicium 21 can be viewed by the camera assembly 14 and the indicium 23 viewed by the camera assembly 16. The object 12 is movable in mutually perpendicular horizontal 'x,y' directions parallel to the sides 19, 18 respectively and in a vertical 'z' direction.

Referring now to Figure 2, a schematic arrangement of a system 25 is shown which includes the camera assemblies 14, 16, digitisers 26, 28 for receiving video signals from the camera assemblies 14, 16 respectively, and a control means in the form of a mini-computer 30 where digitised video signals from the digitisers 26, 28 are received. The mini-computer 30 is connected to an X,Y,Z coordinate read-out unit 32, and to an object drive unit 34 for moving the object 12 to a selected position having coordinates x_1, y_1, z_1 within the enclosure 10. When a visual display is required of the image projected in each camera assembly 14, 16, a television picture screen 36 can be connected between the respective camera assembly 14, 16 and the digitiser 26 or 28.

In operation, each camera assembly 14, 16 transmits to the respective digitiser 26, 28 a video signal representative of the optical image projected in the camera assembly 14, 16, and a digital representation of the video signal is transmitted by the respective digitisers 26, 28 to the mini-computer 30. The mini-computer

30 is programmed to scan the digitised signals received from the digitisers 26, 28 and identify the indicia 21, 23, from which, knowing the focal lengths of the camera assemblies 14, 16, the x,y,z coordinates of the object 12 can be computed and displayed on the read-out unit 32. When the focal lengths of the camera assemblies 14, 16 are variable, appropriate control thereof from the mini-computer 30 and feedback from the camera assmblies 14, 16 to the mini-computer 30 may be provided. If desired, control signals can be supplied from the mini-computer 30 to the object drive unit 34 to control the x,y,z movements of the object 12 and move the object 12 to a selected x,y,z position.

The relationship of the object 12 to the camera assemblies 14, 16 is shown diagrammatically in Figure 3 to which reference is made. In Figure 3, each camera assembly 14, 16 (shown only by lines representing the lens and focal planes thereof) is the same distance 'L' from a point 'O' at the intersection of the principal axes of the camera assemblies 14, 16. Light rays 40, 42 (shown as broken lines) between the object 12 and the camera assemblies 14, 16 respectively impinge on the respective focal planes at distances Δx or Δy from the principal axes of the camera assemblies 14, 16, these distances Δx, Δy being deduced by the mini-computer 30 from the digitised video signals it receives from the digitisers 26, 28.

For camera assembly 14 the equation of the light ray 40 is represented by:

$$x = \frac{-\Delta x}{f}(y+L),$$

and for camera assembly 16 the equation of the light ray 42 is represented by:

$$y = \frac{\Delta y}{f}(x-L),$$

from which the coordinates (x,y) of the object 12 are:

$$x = \frac{L\ (\Delta x.\Delta y - \Delta x f)}{\Delta x \Delta y + f^2}$$

$$y = \frac{-L\ (\Delta x \Delta y + \Delta y f)}{\Delta x \Delta y + f^2}$$

The value of the 'z' coordinate of the object 12 may be deduced by the mini-computer 30 in a similar manner to that aforedescribed when the x,y coordinates of the object 12 are known, from the corresponding distance Δz of either of the light rays 40, 42 on the focal plane of the respective camera assembly 14, 16, and the distance of the camera assembly 14, 16 from the object 12.

The indicium 21 is conveniently provided by a unique coded target or pattern, for example stripes, that can be identified by the mini-computer 30.

When the fields of view of the camera assemblies 14, 16 of Figures 1 to 3 are relatively limited, the camera assemblies 14, 16 may be pivotally mounted so as to pan and tilt about respective vertical and horizontal axes, appropriate corrections being made in the computation of the position of the object 12 by the mini-computer 30, with signals related to the horizontal and vertical angular positions of the camera assemblies 14, 16 being supplied from the camera assemblies 14, 16 to the mini-computer 30 as shown schematically in Figure 2*a* to which reference is made. In Figure 2*a*, a system 25*a* is shown which in most respects is identical to the system 25 of Figure 2, but the horizontal and vertical angular positions of camera assemblies 14, 16 of Figure 2*a* are controlled from a mini-computer 30, and in order to increase the accuracy of resolution of the indicia 21, 23 (not shown) a zoom lens is incorporated in each camera assembly 14, 16. Each zoom lens is controlled by the mini-computer 30 so as to increase the magnification of the zoom lens once the indicium 21 or 23 has ben located by the camera assembly 14, 16 whilst maintaining the indicium 21 or 23 within the field of view of the camera assembly 14, 16 by appropriate adjustment of the angular positions of the camera assembly 14, 16.

It is not necessary for the camera assemblies 14, 16 to be disposed at perpendicular sides of an enclosure, and may for example be disposed at the same side of an enclosure as shown diagrammatically in Figure 4, with the angular positions of the camera assemblies 14, 16 being adjustable as in the arrangement described in Figure 2*a*.

In Figure 4, as in Figure 3, each camera assembly 14, 16 is shown only by lines representing the lens and the focal planes thereof, and principal axes 70, 72 of the camera assemblies 14, 16 respectively, having coordinates $x_1 y_1$ and x_3, y_3 at the respective lens of the camera assemblies 14, 16, intersect at a point 'O' at angles θ and ϕ respectively with a 'y' axis through 'O'. Light rays 74, 76 betw en an object 12 and the respective camera assemblies 14, 16 impinge on the focal planes of the camera assemblies 14, 16 at coordinates x_2, y_2 and x_4, y_4 respectively.

The equation of the light ray 74 is found by the solution of simultaneous equations:

$$mx_1+C=y_1$$
and
$$mx_2+C=y_2$$

from which

$$m=\frac{y_1-y_2}{x_2-x_2}=\frac{f_1\cos\theta-d_1\sin\theta}{f_1\sin\theta+d_1\cos\theta}$$

and
$$c=\frac{x_1y_2-x_2y_1}{x_1-x_2}=\frac{-Pd_1}{f_1\sin\theta+d_1\cos\theta}$$

Thus the general equation of light ray 74 is:

$$y=\frac{1}{f_1\sin\theta+d_1\cos\theta}((f_1\cos\theta-d_1\sin\theta)x-Pd_1) \qquad (1)$$

In a similar manner the general equation of the light ray 76 may be derived as:

$$y=-\frac{1}{f_2\sin\emptyset+d_2\cos\emptyset}(f_2\cos\emptyset-d_2\sin\emptyset)x+Pd_2) \qquad (2)$$

At the intersection of the light rays 74, 76 at the object 12 the solution of the equations (1) and (2) above by the mini-computer 30 provides the 'x,y' coordinates of the object 12, and once these 'x,y' coordinates are known, the 'z' coordinate of the object 12 can be calculated from the vertical angle of the camera assembly 14 or 16 and the calculated distance from the object 12 to the camera assembly 14, 16.

As the focal planes of the camera assemblies 14, 16 in the arrangement Figure 4 would not be parallel to the respective indicium 21 or 23 when used on the object 12, the unique coding of the indicium 21 or 23 might not be preserved on the focal planes. However, knowing θ and d_1 at camera assembly 14, and $\emptyset$ and d_2 at camera assembly 16, appropriate compensation can be made by the mini-computer 30 to allow for the angular disposition of these focal planes.

When a charge-coupled television camera tube is included in the camera assembly 14, 16, the use of a digitiser 26, 28 between the camera assembly 14, 16 and the mini-computer 30 may be dispensed with.

In order to avoid the object 12 striking obstructions in the enclosure 10 of Figure 1, the mini-computer 30 of Figures 2 and 2*a* may be programmed with the coordinates of regions of the enclosure 10 to which movement of the object 12 is prohibited, the object 12 being moved under the control of the mini-computer to avoid these areas.

It will be appreciated that the mini-computer 30 of Figures 2 and 2*a* may be replaced with a dedicated micro-computer, or with some other alternative control means.

CLAIMS

1. A system for detecting the position of a movable object in an environment, the system comprising, at least two camera means for viewing the environment, means for transmitting from each said camera means signals representative of an image in each said camera means, and control means, said control means including means for receiving said signals and for scanning the signals to identify the position of the object in said signals and means for deducing the spatial coordinates of said position with respect to said environment.

2. A system as claimed in Claim 1, wherein the control means includes means for controlling the movement of the object in the environment in relation to said representative signals.

3. A system as claimed in Claim 2, wherein each said camera means is angularly displaceable about mutually perpendicular axes.

4. A system as claimed in Claim 3, wherein the angular displacement of each said camera means is controllable by the control means.

5. A system as claimed in Claim 4, wherein each said camera means includes zoom lens means controllable from the control means.

6. A system as claimed in any one of the preceding Claims, wherein the transmitting means includes digitiser means for digitising the representative signals from the camera means.

7. A system as claimed in any one of the preceding Claims, wherein the coordinates extend in horizontal and vertical planes.

8. A system as claimed in any one of the preceding Claims, including read-out means connectable to the control means for displaying the coordinates.

9. A system as claimed in any one of the preceding Claims, including indicium means attachable to the object, the indicium means comprising a uniquely coded target or pattern.

10. A system as claimed in any one of the preceding Claims, wherein the camera means are disposed in mutually perpendicular relationship.

11. A system as claimed in any one of Claims 1 to 9, wherein the camera means are disposed at the same side of the environment.

12. A method of detecting the position of a movable object in an environment, the method comprising, viewing the environment with two spaced apart camera means, transmitting from the camera means signals representative of images in each said camera means, scanning said signals to identify the position of the object in said signals, and deducing the spatial coordinates of the object from said location.

13. A method as claimed in Claim 12, including panning and/or tilting each said camera means.

14. A method as claimed in Claim 12 or Claim 13, including controlling the movement of the object in relation to said representative signals so as to move the object to a selected position in the environment, said movement being controlled in a manner to avoid the object moving through prohibited portions of the environment.

15. A system for detecting the position of a movable object in an environment, substantially as hereinbefore described with reference to Figures 1, 2, and 3 of the accompanying drawings.

16. A system as claimed in Claim 15, and modified substantially as hereinbefore described with reference to Figure 2*a* of the accompanying drawings.

17. A system as claimed in Claim 16, and modified substantially as hereinbefore described with reference to Figure 4 of the accompanying drawings.

18. A method of detecting the position of a movable object in an environment, substantially as hereinbefore described with reference to Figures 1, 2, and 3 of the accompanying drawings.

19. A method as claimed in Claim 18, and modified substantially as hereinbefore described with reference to Figure 2*a* of the accompanying drawings.

20. A method as claimed in Claim 19, and modified substantially as hereinbefore described with reference to Figure 4 of the accompanying drawings.

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